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Comparison of Refraction Contrast to Absorption Contrast Using Diffraction Enhanced Imaging

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Beamline(s): X15A

Introduction: Images of simple objects have been obtained using Diffraction Enhanced Imaging (DEI)[1,2,3]. The contrast in the enhanced images was quantified and compared to the contrast in images of the objects using conventional synchrotron-based radiography. The comparison, called the DEI gain, is the ratio of the DEI contrast to the conventional radiographic contrast. Until now, there has been no quantified comparison of the improved contrast obtained by either DEI or phase contrast imaging (a similar modality), only qualitative ones[4-7].

Methods and Materials: All images were acquired with 18 keV x-rays on a Fuji HR5 image plate read out using a Fuji BAS2500 Image Plate Reader. Enhanced images also included the use of a silicon analyzer crystal tuned to the [333] plane, located between the detector and the sample stage. Samples used in the experiments included Lucite cylinders and nylon wires. The enhanced images were obtained by imaging the objects with the crystal tuned to either side of the rocking curve and reconstructed according to the algorithm in reference 1. An additional image was acquired with the crystal tuned to the peak of the rocking curve. Contrasts for the peak image and the normal radiograph were measured by taking the ratio of the signal (the difference between the background and the object intensities) to the background intensity. The peak gain was then defined as the ratio of these two contrasts. In order to compare the refraction image and the normal radiograph, signal-to-noise ratios were obtained for each. The refraction gain value was then defined as the ratio of the two SNRs. These gain values were determined at each diameter

Results: Figure 1 shows refraction images, peak images, and normal radiographs of nylon wires of various diameters. A visual inspection clearly shows that both enhanced images clearly show the improved contrast compared to the normal radiograph. Figure 2 is a graph showing the gain values. It is clear from the graphs that the gain values are consistently greater than unity, thereby showing qualitatively the higher contrast of the DEI images compared to the normal radiographs. It is also clear from the graph that the gain values are reduced as the object diameter approaches the full-width half-maximum (FWHM) of the detector's point spread function (PSF), suggesting a limiting factor in the ability of the detector to resolve small objects.

Conclusions: The experiments clearly show the improvements in contrast by DEI compared to normal radiograph. The lower gain values for small diameters can be used as an indicator of the smallest objects that can be resolved using DEI with a given detector. This is an important factor in such applications as mammography, where many calcifications can go unnoticed due to their low contrast and small size. The success of these experiments suggests that DEI can be used to resolve near-pixel-sized objects, such as calcifications, much better than conventional radiographs.

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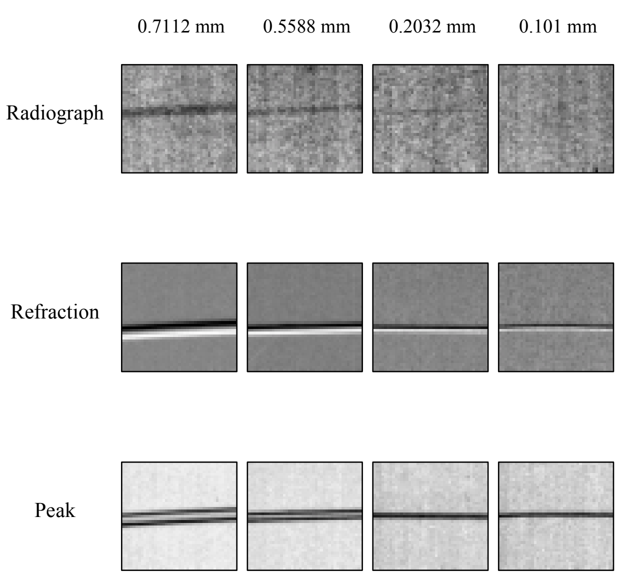

Figure 1. Radiographs and DEI images of nylon wires of various diameters.

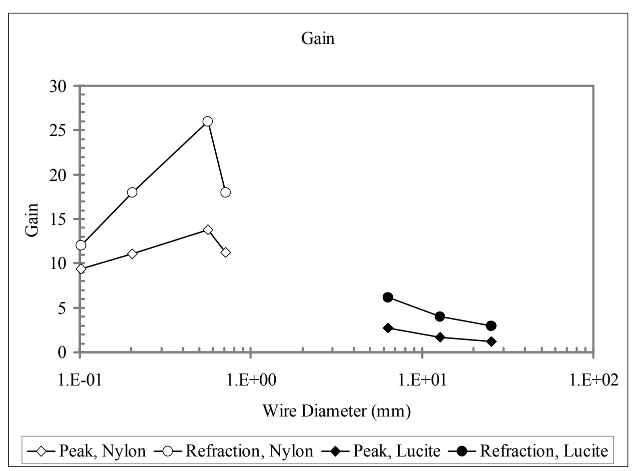

Figure 2. Gain values plotted as a function of object diameter for both refraction and peak.

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